

Braving the Challenges of Being Small *

—The Unique Physics Program at Manhattanville College

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Abstract

We present the formulation and development of the unique physics program at Manhattanville College. By addressing challenges faced by small physics departments in liberal arts colleges, such as the lack of critical mass, lack of significant funding, and under-staffing, we share our efforts and experiences in revitalization of the program into one that is small but of rigor and vitality, with unique features that take advantage of the resources available, including adoption of computer technology in instructional laboratory, collaborations with nearby institutions, and joint efforts with colleagues of other departments/schools. Also included are some discussions on the balance between service and the major, on the relationship with K-12 physics education, and on the rigor of the curriculum, particularly in view of the opposite but converging trends in US and in China.

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I. INTRODUCTION

The outline of the paper is as follows. In Section II, we give a brief introduction to Manhattanville College and its background. In Section III we provide a general overview of the physics program/department at Manhattanville. Section IV contains a more detailed discussion of several special features of the program that make it unique. Section V presents some ideas and plans of future growth as well as some more general discussions on the trends in physics higher education in US and China. We conclude the paper by giving the summary and outlook in Section VI.

II. BACKGROUND AND CURRENT STATUS OF MANHATTANVILLE

Manhattanville College was founded in 1841, originally as a Catholic all-female college. In Spring 1971, it became fully co-educational and non-denominational. Currently it is in essence a residential private liberal arts college.

Manhattanville was initially located in the Manhattanville area of Manhattan, New York City. It later moved into Purchase, Westchester County, NY, about 25 miles north of NYC, a very convenient and attractive location.

The College now has 1,500 full-time undergraduate students, of which about 85% are residential. The student body represents more than three dozens of states and fifty nations. The acceptance rate is at about fifty per cent, with average incoming SAT 1100 and GPA 3.0. More information can be found at the college's web-site at <http://www.mville.edu/>

Manhattanville College's mission is to "educate socially and ethically responsible global leaders". Its general education vision is to provide every student a broad-based liberal arts education, with highly attentive and individualized instructions. As is indicated in New York State regulations, a student need 120 credits to graduate, and 90 of those credits have to be from liberal arts courses for a Bachelor of Arts (BA) degree. A student can get a Bachelor of Science (BS) degree with 60 liberal arts credits (among the total 120)[1].

At Manhattanville, in addition to complying with New York State regulations, we have a set of requirements to further assure that our students come out with well-rounded skill sets: A student needs both a major AND a minor to graduate; he/she needs to fulfill a distribution requirement that he/she must take at least 6 credits each in four area out of the following five: Science & Mathematics, Social Sciences, Humanities, Arts, and Foreign Languages; a student must also fulfill a Global Awareness requirement to broaden his/her visions and understandings beyond his/her own original cultural background.

All these requirement are set up in a well-developed framework called the "Portfolio System", in which the students set out to plan his/her college education together with their advisors from the beginning and have constant checks and adjustments on their plans through out the course of study. This process starts with the freshmen "Preceptorial", a one-year general liberal arts course in essence being "introduction to college learning and life", and then continues till graduation. This structured and flexible approach greatly helps the students along their higher education journey.

III. PHYSICS PROGRAM AT MANHATTANVILLE: AN OVERVIEW

Manhattanville has had a physics program for a very long time. Before the 70s, it was a full undergraduate program with a set of courses offered and both major and minor students. It had a stable faculty size and would graduate several majors each year. The instructional laboratory was also decently established.

However, since the change of nature of the College in the 70's, the physics program went into a continuous declination, till the summer of 1999. At the time, there was only one course offered each semester (the pre-med algebra-based introductory course), the program had no major or minor student(s), the department had zero full-time faculty (the one course was taught by a part time adjunct faculty member), and there had been no new purchase or update of any laboratory equipment.

Starting fall of 1999, with the hiring of the first full-time faculty member in physics in many years, the physics program at Manhattanville underwent a revitalization process. We completely redesigned the whole curriculum, purchased and updated the equipment in the instructional laboratory in a continuous fashion, devoted much efforts in raising the awareness of the program both on and off campus, and attempted different innovative ways in making the program more attractive by tapping into its strengths and circumvent its weaknesses.

As of spring of 2004, the physics program at Manhattanville has become a small but efficient one, with offerings of three different introductory physics courses simultaneously and a set of intermediate physics courses alternating between semesters and academic years. With a stable physics minor student body and the emerging major enrollment, advanced level courses will also soon become a regular part of the course offerings. On the facility side, we have updated and rebuilt much of the introductory instructional laboratory with newly purchased instruments. We have also developed a computer-based instructional laboratory and a summer research internship, both to be covered in more detail later, to provide the experimental training students need. Currently the program is running smoothly and successfully at full capacity with one full-time and one part-time adjunct faculty members. It is posed in a ready position to develop further once the situations in funding and staffing are ready.

IV. SPECIAL FEATURES OF THE PHYSICS PROGRAM

The Physics Program at Manhattanville has many unique features that set it apart from any other program in the country. First of course is its small size [2], which is both the source of its strength and uniqueness and the origin of the challenges and difficulties it faces. We tried to develop a program that utilizes any and all the resources that we could draw upon, and have indeed been successful in achieving a nice balance under the many constraints.

A. The Major Program

The redesigned physics major requires 54 mandatory credits total, which includes a large 16-credit mathematics co-requisite. This means the physics requirement is 38 credits, quite in line with other liberal arts (including science) majors at the college. It is expected that

the requirements could be finished reasonably by a student in either four or (even) just three years.

The required course structure is: one year of calculus based introductory physics sequence (University Physics I & II, $2 \times 4\ cr$); the intermediate physics core consisting of four 2000 level courses (Mechanics, Electromagnetism, Quantum Physics, and Thermodynamics & Statistical Physics, $4 \times 4\ cr$); two advanced electives chosen from a set of 3000 level special topic courses (eg, Advanced Mechanics, Quantum Mechanics, Solid State Physics, etc, $2 \times 4\ cr$); one summer research internship ($3\ cr$); and the senior research seminar with a thesis ($1 \times 3\ cr$ or $2 \times 1.5\ cr$). The mathematics courses are Calculus I, II & III, and Ordinary Differential Equations ($4 \times 4\ cr$). There is also a minor program that requires the one year introductory sequence, two intermediate physics courses, and a one year calculus sequence (Calc I & II). Students are encouraged to take more advanced mathematical courses like Linear Algebra or Complex Variables, some physical or other science courses like General Chemistry and/or Biology to deepen and/or broaden their scientific background.

With a program set up like the above, the students, while receiving rigorous training, also have the freedom to adjust and streamline their course of study to match their own general study plan (the "Portfolio", see II). They can, for example, choose the timing of the summer internship, even opt to do an extra one; pace themselves a bit by taking just one intermediate core course a semester while fulfilling other college requirements or pursuing their other interests in liberal arts; or structure their senior research in either an intense one semester or a thorough two semester fashion. Having both high-standard courses and different structural options, the major/minor program at Manhattanville is one of rigor and flexibility.

B. The Service Courses

Besides the rigorous calculus based introductory physics sequence, the department also offers on a regular basis two other one-year introductory physics courses. One is the also rigorous algebra based "College Physics" sequence, mainly intended for students in various pre-health programs and/or biological sciences. It in fact has the largest enrollment of all physics courses at Manhattanville, and is the most important service course of the department.

The other service course is a conceptual introduction to physics and astronomy intended for general liberal arts students. Such a course engages students from the broadest spectrum and focuses on three aspects:

- The methodology of physics: Illustrating the scientific approach to a vast array of different problems.
- The knowledge body: Going over major developments of mechanics and modern astronomy. Emphasis is on basic ideas and concepts rather than techniques of problem-solving.
- Relationship to everyday-life: Giving the students an appreciation of how to evaluate the merit (or lack of merit) in arguments presented in current scientific controversies, such as debates about the environment, about energy usage and conservation, about evolution, etc.

The sequence has been a success since its inaugural year in 2000-2001. It is now being offered each year and is taught by a part-time adjunct faculty.

Indeed, all three introductory sequence at Manhattanville have stable enrollment. We are pleased to be able to offer them to meet the needs of our diverse student body within such a small department.

C. The Summer Internship

The summer research internship mentioned above is a unique feature of the physics program at Manhattanville. Due to the status of the instructional laboratory, staffing and budgetary constraints at the college and departmental levels, full fledged intermediate and/or advanced laboratory courses as part of the curriculum are unpractical at least for the moment. On the other hand, the convenient location of Manhattanville—close proximities to New York City and major research institutions therein—brings about many opportunities.

We took advantage of the close ties between our faculty members and those at Physics Department of Columbia University in NYC and established a collaboration with Columbia. Our major students will take summer research internship course(s) in the summer(s) after their sophomore year and/or junior year as supplements to the theoretical courses. The students will be engaging in actual research activities at the Nevis Research Laboratory of Columbia University, located in Irvington NY, even closer to Manhattanville, by joining as interns one of the groups working there.

Such experiences will be extremely beneficial to the development of students in many ways. They are being put into an active scientific environment that facilitates interactions with researchers and peer students. They are also being exposed to modern experimental instrumentation, techniques and methods. The summer research internship will be an important and effective method for the students to obtain the necessary laboratory experiences and training, in lieu of the conventional intermediate and advanced laboratory courses. In the long run, it will be an unique and integral part of the whole experimental training aspect of the program.

D. The Computer-based Laboratory

One of the innovative ways in physics education has been the application of computer technology in course instruction. We have started to develop a computer-based instructional laboratory component in addition to conventional methods. Students will be engaging in computer-based data acquisition and analysis and performing computer simulated intermediate and advanced experiments otherwise not accessible to them. This is another effective and innovative method of providing the needed training under our constraints.

Currently we have three laboratory stations set up, each with a PASCO physics (USB) 750 interface bundle and a Dell small-form desktop computer. They are going to be fully integrated into the curriculum starting fall of 2004, with students performing experiments using them in rotation. This puts us in a leading position among comparable institutions on this aspect, and in the long term will be another integral and complementary part of the physics program.

V. OPPORTUNITIES AND CHALLENGES

The Physics program is currently running at its full capacity efficiently. Besides the continued efforts in trying to increase enrollments of major and non-major students and in upgrading, updating and expanding the laboratory, we are also looking ahead for opportunities of growth and further development.

One such great opportunity is collaboration with our School of Education. Higher standards from New York State Department of Education for future teachers (K-12) are being implemented in schools throughout the state, representing a national trend of raised awareness of the importance of better teacher education, especially in sciences. The new standard require disciplinary content equivalent to a undergraduate major, and in particular for physics, 32 credits (including 8 in mathematics). The School of Education at Manhattanville is very successful with great reputation and track record. We have taken advantage of this opportunity and developed, in collaboration with the School of Education, both an undergraduate educational track physics major and an Mater of Arts in Teaching (MAT) program in physics. These may lead to potential significant numbers of students for the physics program in the upcoming years.

Another mid-long term planning of our program has development of interdisciplinary programs in mind. The 21st century has seen the emergences and rapid expansions of many interdisciplinary fields, as well as the ever-growing significance in fields like biological and material sciences. We want to tap into the strengths of existing programs at Manhattanville and develop new and exciting interdisciplinary programs. One such example would be a program in applied mathematical physics. Manhattanville has excellent programs in both computer science and mathematics. By collaboration with the Department of Computer Science and Mathematics, we plan to develop a strong and appealing program that provide students with knowledge in physics and mathematics, abilities in abstract and quantitative analysis, and skills in applied mathematics and computer science. Such a combination will be an attractive option for the students, facing the technology intensive economy and job market. Other programs being considered including bio-physics, bio-informatics, and chemical physics.

The biggest challenges facing the Department are two-fold. First, the lack of critical mass in both the faculty and the students. We are actively engaged in various methods of recruiting and retaining students, hoping to further increase our student body. At the same time, the eventual increase of faculty size is also a priority of the department. The second is lack of significant development funding. While we have achieved a lot under current budget constraints, major growth in facilities and/or faculty size still need major funding. We expect to receive continued support from the college administration on these efforts, at the same time of actively seeking external funding as well.

VI. SUMMARY AND OUTLOOK

The Physics Program at Manhattanville is one of unique features and strengths—the collaborative summer research internship and the computer-based instructional laboratory being two, despite its small size. Students in the program will receive rigorous and highly individualized training in both theoretical and experimental aspects of the discipline.

On a bigger scale, enrollment in physics courses in K-12 education has started to increase[3]. This is an indication of a national trend in the heightened importance peo-

ple starting to assign to sciences and physics in particular. The direct result is the potential larger enrollment for physics programs and the requirement of more rigorous curricula in physics. On an even larger scale, globally sciences and physics in particular are, more than ever, recognized as the underlying driving force of development and advancement in economics and technology. The theme is to find the best way of educating students in seeking the balance of knowledge body and methodology. China, for example, is starting to turn away from its traditional high-intensity, large-depth, narrow-focus approach of physics undergraduate education, and beginning to experiment in a more broad-based, liberal arts oriented approach. For example, the "Science Platform" at Fudan University[4], one of the top comprehensive universities in China, is such an attempt by requiring all science majors to take biology, physics and chemistry in their first year. It is not clear yet what the best balance is, but this presents opportunities for discussion, research and collaboration within the physics community, or even the whole science community, at a global scale.

We are confident that with the increasing awareness of the physics program, the continued pursuit of excellence and innovation, and the constant seeking of collaboration and cooperation, the program will, riding the favorable trend statewide, nationally and internationally, expand and grow and have a bright future.

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- [1] For details on liberal arts courses and so on, please refer to the relevant regulations of New York State Education Department.
 - [2] For example, at both the 2003 and 2004 American Institute of Physics Conferences of Physics Department Chairs, Manhattanville's Physics Department was the smallest with only one full-time faculty member.
 - [3] Statistics provided by AIP at the 2004 Physics Department Chairs Conference, "*Physics in the Public Interest*".
 - [4] F. Lu, R. Su, and R. Tao, private communications.